

Index

Note: Page numbers in *italics* refer to Figures. Page numbers in **bold** refer to Tables.

- acoustic measurements on Etna
 - method 107
 - results 107–109
 - synthesis
 - acoustic sensitivity of 136–137
 - bubble vibration 109–111
 - explosion evolution 111–113
 - gas behaviour
 - degassing 115–119
 - ejecta 119–120
 - volume 113–115
 - volume time evolution 120–121
 - gas flux 133
 - surface activity measurements compared 136
- acoustic waves 45
- Akaike's Information Criterion (AIC) 60, **194**, 196
- Arenal volcano 103
- Asama, Mount
 - 2004 activity 189–190, 193
 - seismic network 190, 193
 - seismic signal analysis
 - methods 193–194
 - models 194
 - results
 - assuming point source 194–198
 - assuming separated sources 198
 - results discussed
 - conservation of total linear momentum 199–202
 - 6Mom component 202–205
 - source time history 198–199
 - setting 189
- atmosphere, responses to eruption 1
- attenuation *see* quality (Q) factor
- basaltic eruptions 125
- basaltic magma, behaviour in fissures and dykes
 - numerical modelling 34–35
 - simulation
 - characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43
- bubbly magma
 - bubble diameter and degassing equation 131, 132
 - Etna characteristics **128**
 - Kilauea characteristics **129**
 - modelling bubble vibration 109–111
 - pressure wave behaviour in
 - analytical solutions
 - Q factor for no mass flux conditions 15–16
 - Q factor for mass flux conditions
 - diffusive regime 17–18
 - equilibrium regime 18–19
 - viscous regime 16–17
 - numerical solutions 19–20
 - solutions discussed
 - elastic deformation 23–24
 - equilibrium frequency state 20–23
 - $Q(f)$ depth profile 25–26
 - very low frequency 24
 - visco-elastic solution 24–25
 - theory
 - bubble growth dynamics 13–15
 - bubble growth model 28–30
 - Q factor 13
 - saturated bubbly magma 13
 - wave equation 11–13, 26–28
- cataclastic rocks 172
- Colima 228
- computational fluid dynamics (CFD) model 154–155
- convective motion and fluid oscillation
 - numerical modelling 34–35
 - simulation
 - characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43
- crack waves 45, 54
- crystal zonation 1
- curtain of fire 125
- cyclic activity *see* Soufrière Hills Volcano
- Deborah number 14
- deformable channels and flow 46
 - modelling
 - clarinet modes 51–53
 - roll waves 46–50
 - wall modes 50–51
 - models reviewed 53–54
- deformation *see* ground deformation
- degassing
 - Etna behaviour 132–133
 - acoustic and surface activity data compared 136–137
 - foam behaviour 133–134
 - gas flux 133
 - gas volume fraction 135
 - height 135
 - surface area 134–135
 - time evolution 135–136
 - Kilauea thermal signals 87–89
 - numerical modelling 131–132
 - passive v. active 115–119
 - Soufrière Hills Volcano stick-slip cycles and 171–173
 - model 173, 173–181
 - parameters **175**
 - model results discussed 181–185
- density of magma and convection in fissures
 - numerical modelling 34–35
 - simulation
 - characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43

- diffusion in bubbly magma 14, 16, 17
diffusion pumping, significance of laboratory experiments 223–224, 229–231
diffusivity, water 14
dome growth
 analogue modelling
 method 208–210
 results 210–211
 results discussed
 diffusion pumping 223–224
 exsolving flow 211–213
 flow expansion 216–217
 flow structure 213–216
 impulsive events 217–219
 permeability 216
 pressure cycles 220–223
 pressure gradients 219–220
 vesicularity 216
 significance of results
 diffusion pumping 229–231
 explosive behaviour 231–232
 explosivity timescale 224–225
 magma plug motion 232–234
 pressure gradients 225–226
 tilt cycles 228–229
 vesicularity, density and permeability 226–228
numerical modelling at Soufrière Hills Volcano 173
 conduit deformation 176–178
 depressurization 178–181
 parameters **175**
 pressure and forces 173–174
 pressurization 174–176
 results discussed
 depressurization 183
 limitations 185
 pressurization 181–183
 regimes 184–185
dykes *see* fissures
elastic waves 45
Erebus volcano 2
Etna volcano 6
 122BC eruption 104
 1989 eruption 104
 2001 eruption 104
 acoustic measurements
 method 107
 results 107–109
 acoustic synthesis
 bubble vibration 109–111
 explosion evolution 111–113
 gas behaviour
 degassing 115–119
 ejecta 119–120
 volume 113–115
 volume time evolution 120–121
 behaviour 130–131
 description 105–107
 reservoir degassing 132–133
 acoustic and surface activity compared 136–137
 foam behaviour 133–134
 gas flux 133
 gas volume fraction 135
 height 135
 surface area 134–135
 time evolution 135–136
 vent parameters **112**
 behaviour over time 125–126
 comparisons with Kilauea 142–143
degassing characteristics **128**
degree of unsteadiness 127
fire fountains 104, 105
foam disruption 104
gas volume 128–129
quasi-fire fountains 105
reservoir depth 127–128
volatiles content 105
excess pressure *see* overpressure
explosive behaviour, significance of laboratory experiments 224–225, 231–232
finite shell model 30
fire fountain 104, 105, *106*
 equations for height 127
 Etna v. Kilauea 125, 126, 127
 Kilauea 137, 139, 140
 transition to Strombolian activity 130
fissures, modelling of convective motion in 34–35
simulation
 characteristics 35–36
 results 36–38
 impact on ground deformation 38–40
 results discussed 41–43
flow 1, 2
 hydrodynamic instabilities and oscillations, flow-induced 46
 modelling
 clarinet modes 51–53
 roll waves 46–50
 wall modes 50–51
 models reviewed 53–54
 laboratory experiments
 method 208–210
 results 210–211
 results discussed
 boiling/exsolving 211–213
 expansion 216–217
 structure 213–216
 see also lava flow
fluid inclusions, Etna 128–130
fluid oscillation and convective motion
 numerical modelling 34–35
 simulation
 characteristics 35–36
 results 36–38
 impact on ground deformation 38–40
 results discussed 41–43
foam
 behaviour at Etna 126, 130, 131, 133–134
 collapse and gas slug formation 98–99
 expansion and impulsive events 217–219
force systems and seismic signals 194
GALES code 34
gas chemistry 1

- gas piston events
 - Kilauea
 - 2001–2003 events 89–90, 93–96
 - classification 96–97
 - evolution of 97–99
 - first recorded 85–86
- gas slug
 - behaviour 4
 - defined 109–110, 132, 133
 - formation by foam collapse 98–99
 - modelling 147–148
 - methods 148–149
 - 1-D numerical 151–154
 - 3-D CFD 154–155
 - laboratory 149–151
 - results
 - conduit force effect 160–162
 - gas mass effect 157–159
 - laboratory v. numerical 156–157
 - vent radius effect 159–160
 - results discussed
 - ascent and expansion 162–164
 - burst overpressures 164
 - conduit forces 164
 - summary of model achievements 164–165
 - pressure changes 5
 - space–time history 6
- gas volume
 - flux equations 131
 - from acoustic measurements 113–114, 127
 - from surface activity 114–115, 127
 - relation to fire fountain 127
 - relation to fluid inclusions 128–130
 - time evolution of 120–121
- gravitational instability
 - causes 33
 - fluid oscillation and convective motion
 - numerical modelling 34–35
 - simulation
 - characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43
- gravity anomaly 125
- Green's functions 58, 59, 60
- ground deformation, relation to magma convection
 - numerical modelling 34–35
 - simulation
 - characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43
- ground motion, relation to fluid flow 2, 3
- gum rosin acetone (GRA) 208
- gum rosin diethyl ether (GRDEE) 208, 209, **211**
- Hawaiian-type eruption 2, 105, 126
- Henry's constant 14
- hybrid earthquakes 169
- ideal gas law 14
- infrared thermometers, use on Kilauea 86–87
- Karymsky volcano 103
- Kelvin model, for visco-elasticity 16, 18
- Kilauea volcano
 - behaviour 125, 126
 - carbon dioxide emissions 105
 - comparisons with Etna 142–143
 - degassing characteristics **129**
 - degree of unsteadiness 127
 - eruptive events compared 140–142
 - gas volume 130
 - ground motion 2, 3
 - Kilauea Iki eruption 137–139
 - Mauna Ulu eruption 85, 126, 139–140
 - Pu'u 'O'o eruption 85, 126, 140
 - gas piston activity 85–86
 - thermal recording
 - method 86–87
 - results
 - degassing 87–89
 - gas piston events 89–90
 - lava flows 87
 - results discussed
 - gas piston event classification 96–97
 - gas piston event trends 93–96
 - lava flow thermal levels 91–93
 - significance of results 97–99
 - reservoir depth 127–128
 - thermal emission 6
- Krakatau 1
- laboratory experiments
 - bubble studies 2–5
 - dome growth
 - method 208–210
 - results 210–211
 - results discussed
 - diffusion pumping 223–224
 - exsolving flow 211–213
 - flow expansion 216–217
 - flow structure 213–216
 - impulsive events 217–219
 - permeability 216
 - pressure cycles 220–223
 - pressure gradients 219–220
 - vesicularity 216
 - significance of results
 - diffusion pumping 229–231
 - explosive behaviour 231–232
 - explosivity timescale 224–225
 - magma plug motion 232–234
 - pressure gradients 225–226
 - tilt cycles 228–229
 - vesicularity, density and permeability 226–228
- gas flow and seismic signals 50, 51, 52
- gas slug expansion
 - method 149–151
 - results 156–157
 - conduit force effect 160–162
 - gas mass effect 157–159
 - vent radius effect 159–160
- gas slug flow 116–117
- lava flows, thermal signals on Kilauea 87, 89, **90, 91–93**

- long-period (LP) seismic events *see* seismicity
- lumped-parameter model 46
- magma
- density and convection in fissures
 - numerical modelling 34–35
 - simulation
 - characteristics 35–36
 - results 36–40
 - results discussed 41–43
 - flow 1, 2
 - see also* flow
 - plug motion 172
 - significance of laboratory experiments 232–234
 - reservoir depth at Etna 127–128
 - viscosity
 - behaviour of high 6–8
 - behaviour of low 2–6
 - and bubble growth 14, 19–20
 - volume, numerical modelling of 119–120
 - see also* basaltic magma *also* bubbly magma
- Mauna Ulu *see under* Kilauea volcano
- Maxwell model for visco-elasticity 16, 18
- Maxwell relaxation time 14
- modelling
- analogue *see* laboratory experiments
 - numerical *see* numerical modelling
- Navier–Stokes equation 34
- numerical modelling
- bubble vibration 109–111
 - model and acoustic data compared 111–113
 - convective motion and fluid oscillation 34–35
 - simulation
 - characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43
 - cyclic activity of Soufrière Hills Volcano
 - description 169–170
 - gas pressurization 171
 - model 173
 - conduit deformation 176–178
 - depressurization 178–181
 - parameters **175**
 - pressure and forces 173–174
 - pressurization 174–176
 - model results discussed
 - depressurization 183
 - limitations 185
 - pressurization 181–183
 - regimes 184–185
 - stick-slip 171–173
 - time period 170–171
 - degassing 131–132
 - gas slug expansion 147–148
 - methods 148–149
 - 1-D numerical 151–154
 - 3-D CFD 154–155
 - results
 - conduit force effect 160–162
 - gas mass effect 157–159
 - laboratory *v.* numerical 156–157
 - vent radius effect 159–160
 - results discussed
 - ascend and expansion 162–164
 - burst overpressures 164
 - conduit forces 164
 - summary of model achievements 164–165
 - gas volume and fire fountain height 127
 - magma volume 119–120
 - pressure waves in bubbly magma
 - analytical solutions
 - Q factor for no mass flux conditions 15–16
 - Q factor for mass flux conditions
 - diffusive regime 17–18
 - equilibrium regime 18–19
 - viscous regime 16–17
 - numerical solutions 19–20
 - solutions discussed
 - elastic deformation 23–24
 - equilibrium frequency state 20–23
 - $Q(f)$ depth profile 25–26
 - very low frequency 24
 - visco-elastic solution 24–25
 - theory
 - bubble growth dynamics 13–15
 - bubble growth model 28–30
 - Q factor 13
 - saturated bubbly magma 13
 - wave equation 11–13, 26–28
 - waveform inversion at Stromboli
 - method 59–61
 - results
 - single crack solution 61
 - two crack solution 61–67
 - two point source solution 67–78
 - significance of results 78–82
- oscillations, flow-induced 46
- modelling
- clarinet modes 51–53
 - roll waves 46–50
 - wall modes 50–51
- models reviewed 53–54
- overpressure, defined 207
- permeability, significance of laboratory
 - experiments 216, 226–228
- Pinatubo, Mount 103, 228
- plug motion *see under* magma
- Poiseuille flow 231
- Popocatepetl 103, 228
- pressure
- build-up and stick-slip cycles at Soufrière Hills
 - Volcano 171–173
 - model 173, 173–181
 - parameters **175**
 - model results discussed 181–185
 - in flows, significance of laboratory experiments
 - 219–223, 225–226
- pressure in fissures, relation to magma convection
- numerical modelling 34–35
- simulation
- characteristics 35–36
 - results 36–38
 - impact on ground deformation 38–40
 - results discussed 41–43

- pressure wave attenuation and propagation in bubbly liquid
- analytical solutions
 - Q factor for no mass flux conditions 15–16
 - Q factor for mass flux conditions
 - diffusive regime 17–18
 - equilibrium regime 18–19
 - viscous regime 16–17
 - numerical solutions 19–20
 - solutions discussed
 - elastic deformation 23–24
 - equilibrium frequency state 20–23
 - $Q(f)$ depth profile 25–26
 - very low frequency 24
 - visco-elastic solution 24–25
 - theory
 - bubble growth dynamics 13–15
 - bubble growth model 28–30
 - Q factor 13
 - saturated bubbly magma 13
 - wave equation 11–13, 26–28
- Pu'u 'O'o eruption *see under* Kilauea volcano
- pyroclastic morphology 1
- quality (Q) factor
- depth profile 25–26
 - mass flux conditions
 - diffusive regime 17–18
 - equilibrium regime 18–19
 - viscous regime 16–17
 - no mass flux conditions 15–16
 - theory 13
- quasi-fire fountain 125–126, 127
- relative seismic amplitude measurement (RSAM) 170
- resonance and resonant bodies *see* oscillations, flow-induced
- Reynolds number 116, 117
- rheology of magma, no mass flux solutions 16
- roll waves 46
- modelling 46–50
 - roll waves 46–50
 - wall modes 50–51
 - models reviewed 53–54
- seismicity, very-long period (VLP)
- imaging of Stromboli 58–59
 - method 59–61
 - results
 - single crack solution 61
 - two crack solution 61–67
 - two point source solution 67–78
 - significance of results 78–82
- Shishaldin volcano 103, 104, 126, 131
- sloshing waves 108–109
- Soufrière Hills Volcano 2, 7
- cyclic activity
 - description 169–170
 - gas pressurization 171
 - stick-slip modelling 171–173
 - conduit deformation 176–178
 - depressurization 178–181
 - parameters **175**
 - pressure and forces 173–174
 - pressurization 174–176
 - stick-slip model discussed
 - depressurization 183
 - limitations 185
 - pressurization 181–183
 - regimes 184–185
 - time period 170–171
 - plug 226
 - spine growth 234
 - tilt cycles 228, 230, 231, 232
 - vesicularity 227, 229
- sound-wave recording *see* acoustic measurements
- spine growth 234
- stick-slip cycles at Soufrière Hills Volcano 171–173
- model 173
 - conduit deformation 176–178
 - depressurization 178–181
 - parameters **175**
 - pressure and forces 173–174
 - pressurization 174–176
 - model results discussed
 - depressurization 183
 - limitations 185
 - pressurization 181–183
 - regimes 184–185
- Stromboli 2–6
- explosions 103
 - imaging by waveform inversion
 - method 59–61
 - results
 - single crack solution 61
 - two crack solution 61–67
 - two point source solution 67–78
 - significance of results 78–82
 - magmatic column composition 33
 - setting 58–59
- Strombolian-type eruption 2, 33, 105, 147
- Etna 125, 130–131
- Subplinian-type eruption 104, 126, 131
- sulphur dioxide emission 170
- superstatic pressure *see* overpressure

- thermal recording at Kilauea 85
 - method 86–87
 - results
 - degassing 87–89
 - gas pistons 89–90
 - lava flows 87
 - results discussed
 - gas piston event trends 93–96
 - lava flow thermal levels 91–93
 - results discussed gas piston event classification 96–97
 - significance of results 97–99
- thermal signature 1
- thermals on Etna defined 126, 130–131
- tilt cycles 228–229
 - modelling at Etna 127
 - Soufrière Hills Volcano 7, 169, 170–171
- tremor anomaly 125

- unsteadiness, degree of, defined 127
- Unzen volcano 58, 172

- very-long period (VLP) seismic events *see* seismicity
- vesicularity
 - Etna v. Kilauea 126
 - significance of laboratory experiments 216, 226–228
- visco-elasticity, Kelvin v. Maxwell 16, 18, 20
- viscosity of magma
 - behaviour of high 6–8
 - behaviour of low 2–6
 - and bubble growth 14, 19–20
- volcanic earthquakes 26
- volcanic explosive index (VEI) 1–2
- vulcanian-type activity 103
 - Mount Asama 189–190, 193
 - seismic signal analysis
 - methods 193–194
 - models 194
 - results
 - assuming point source 194–198
 - assuming separated sources 198
 - results discussed
 - conservation of total linear momentum 199–202
 - 6Mom component 202–205
 - source time history 198–199
 - Soufrière Hills Volcano 170, 226
- wake 116
- water
 - diffusivity in bubbly magma 14
 - magma content of 2
- wave equation, for bubbly liquid 11–13, 26–28
- waveform analysis at Mount Asama
 - methods 193–194
 - models 194
 - results
 - assuming point source 194–198
 - assuming separated sources 198
 - results discussed
 - conservation of total linear momentum 199–102
 - 6Mom component 202–205
 - source time history 198–199
- waveform inversions, imaging of Stromboli
 - 58–59
 - method 59–61
 - results
 - single crack solution 61
 - two crack solution 61–67
 - two point source solution 67–78
 - significance of results 78–82
- Weber number 117